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(54) **AXLE ASSEMBLY HAVING DIFFERENTIAL ASSEMBLY WITH INVERTED DIFFERENTIAL BEARINGS**

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(51) **Int. Cl.**

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F16H 48/06	(2006.01)
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F16H 48/38	(2012.01)

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CPC ***B60B 35/125*** (2013.01); ***B60B 35/16*** (2013.01); ***F16H 48/06*** (2013.01); ***F16H 48/38*** (2013.01); *B60Y 2200/20* (2013.01)

(58) **Field of Classification Search**

None

See application file for complete search history.

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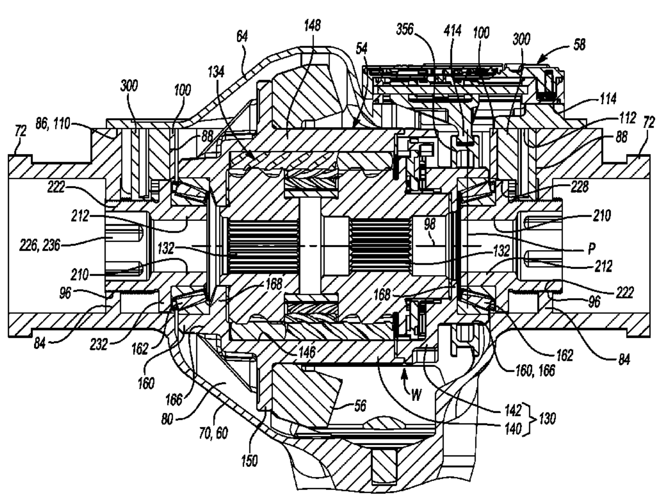
(57) **ABSTRACT**

An axle assembly having a carrier housing, a pair of axle tubes, a differential case, a pair of differential bearings and a pair of bearing adjusters. The carrier housing includes a cavity, which is configured to receive the differential case, and a pair of axle tubes that are mounted to the carrier housing. The differential case includes bearing bores into which the outer races of the differential bearings are received. The bearing adjusters are threaded to the carrier housing and support the differential bearings on a side opposite the differential case.

23 Claims, 10 Drawing Sheets



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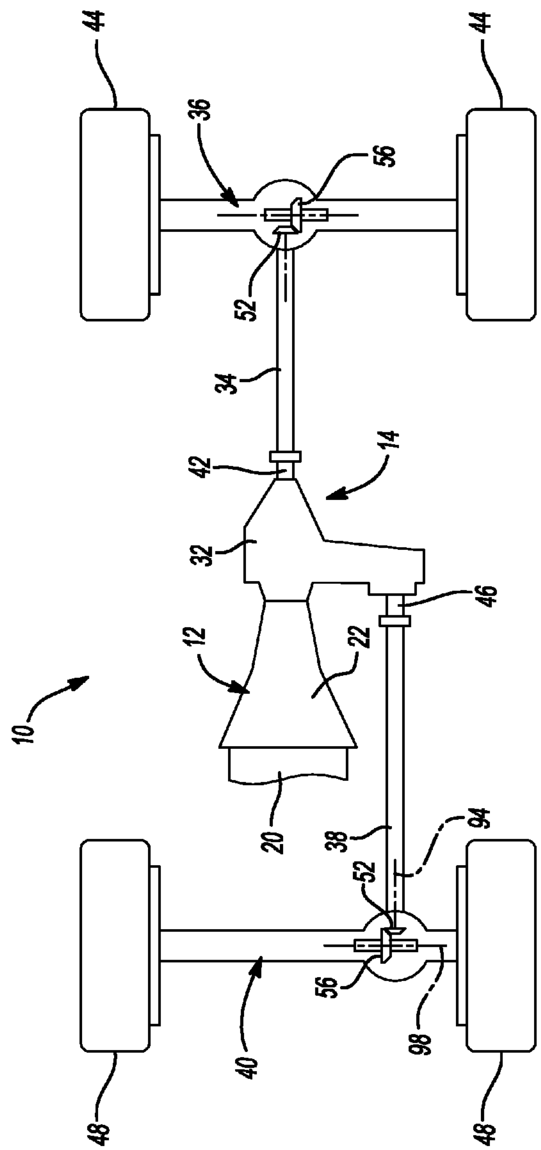


Fig-1

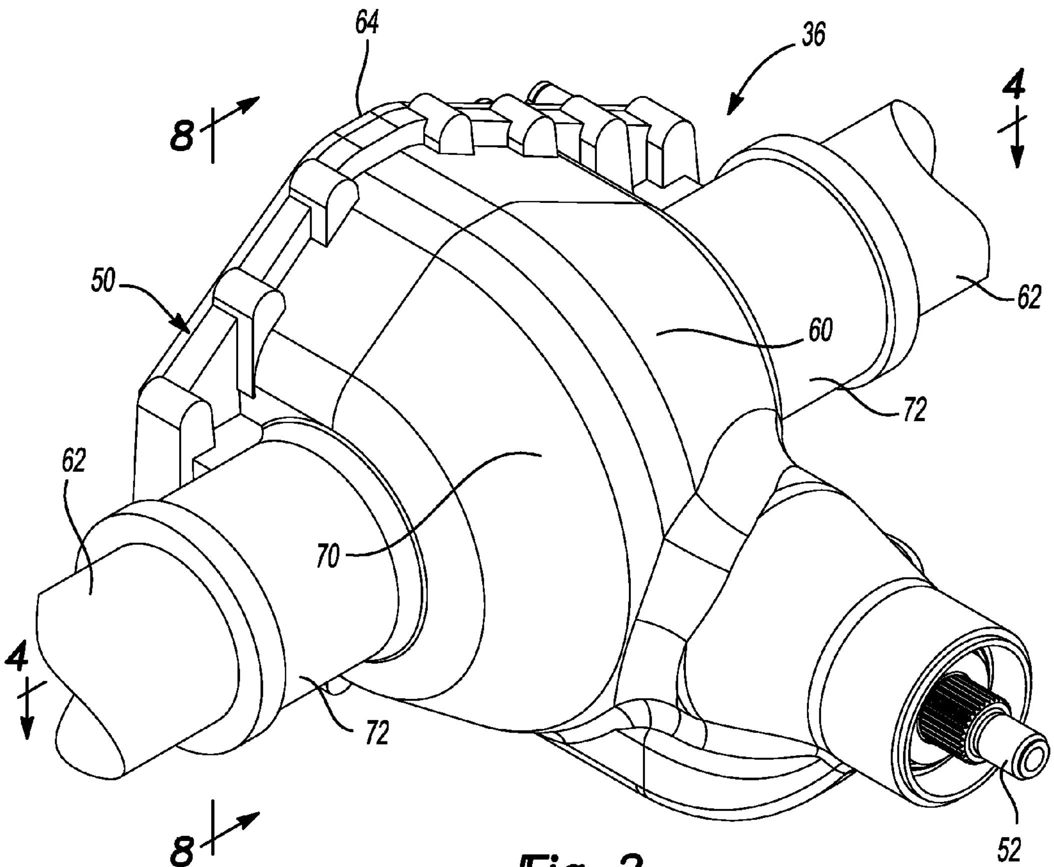
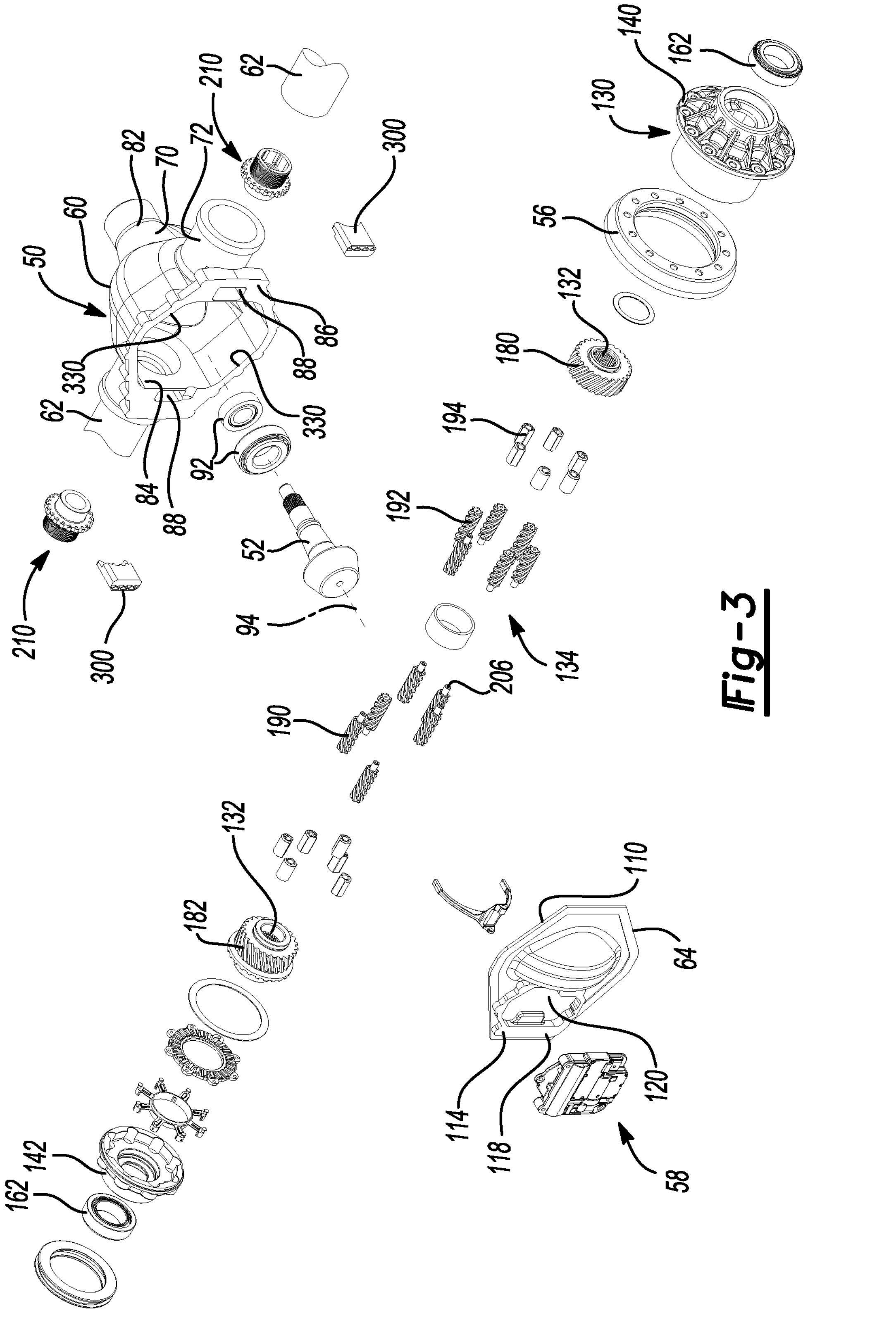


Fig-2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132
180
194
210
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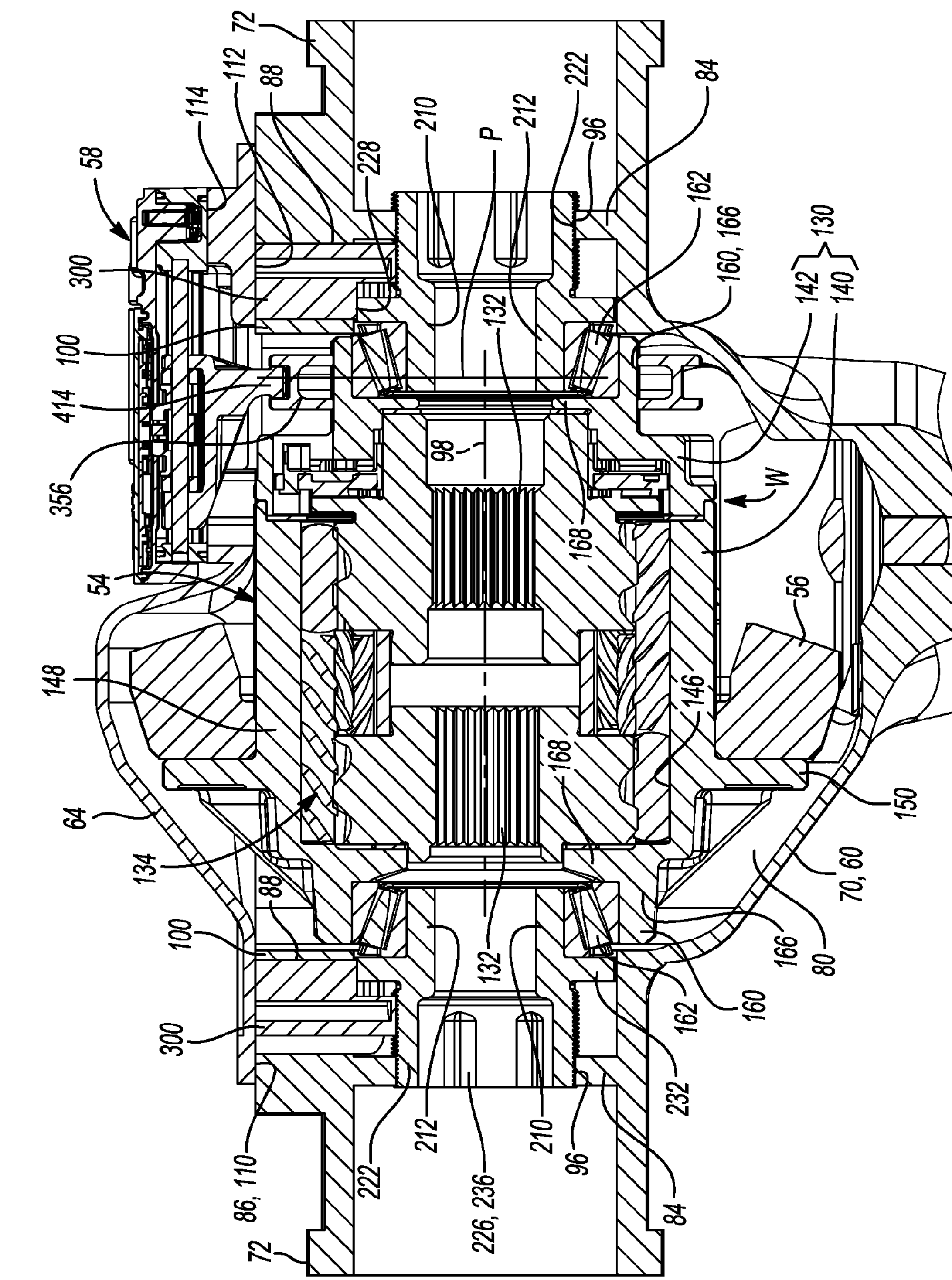
Fig-3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160, 166
160, 162
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166
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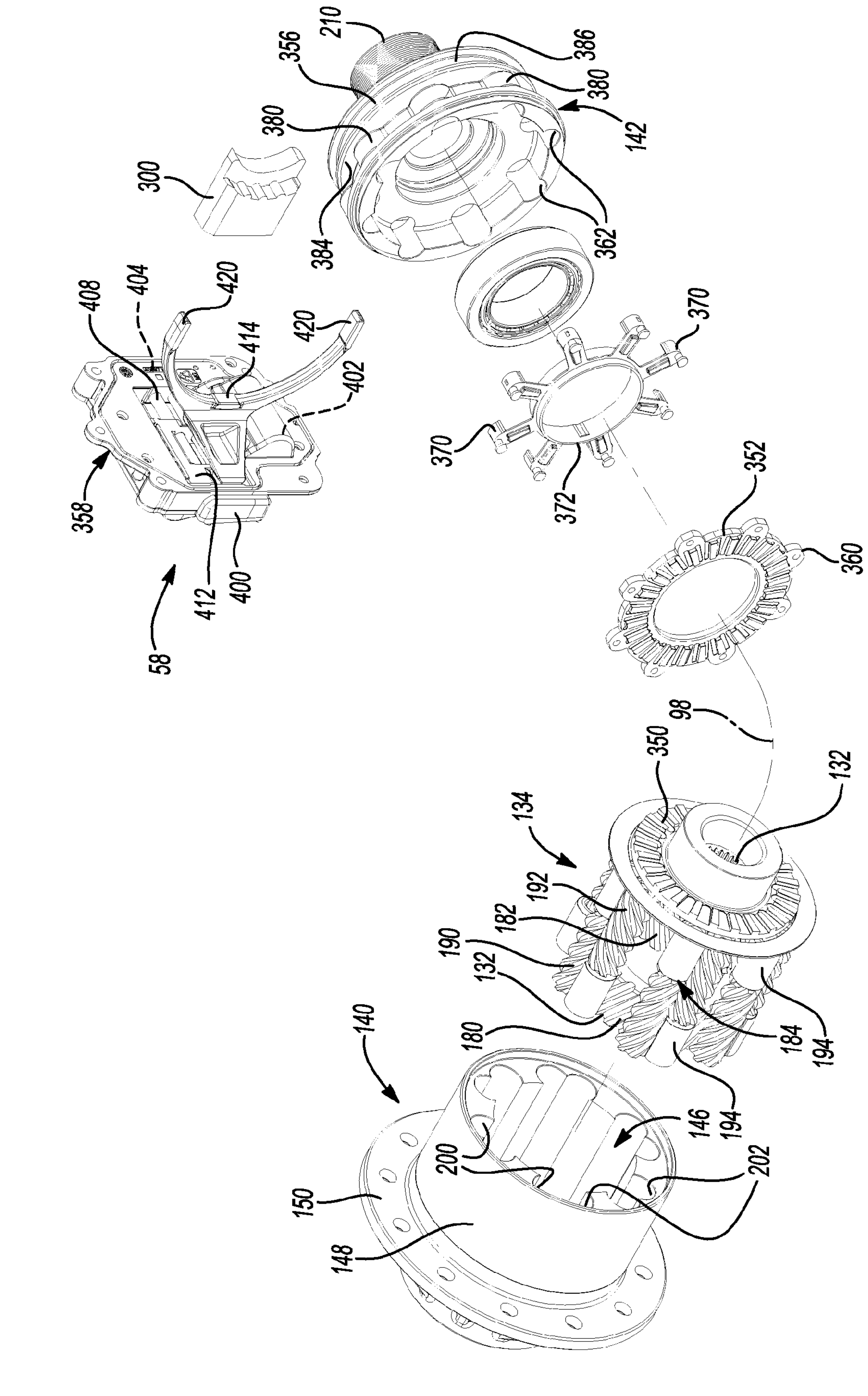
162
232

Fig-4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360
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148

Fig-5

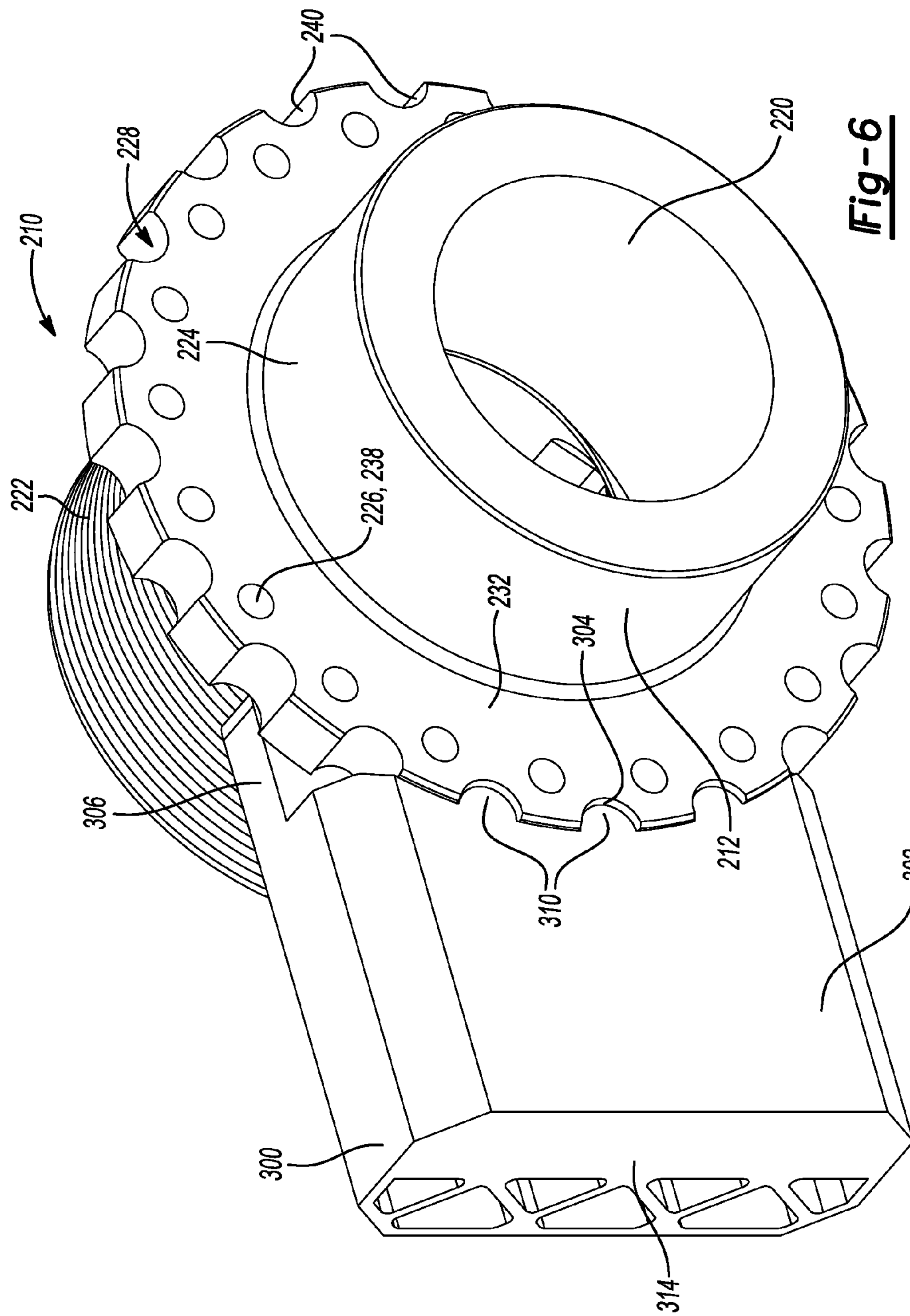


Fig-6

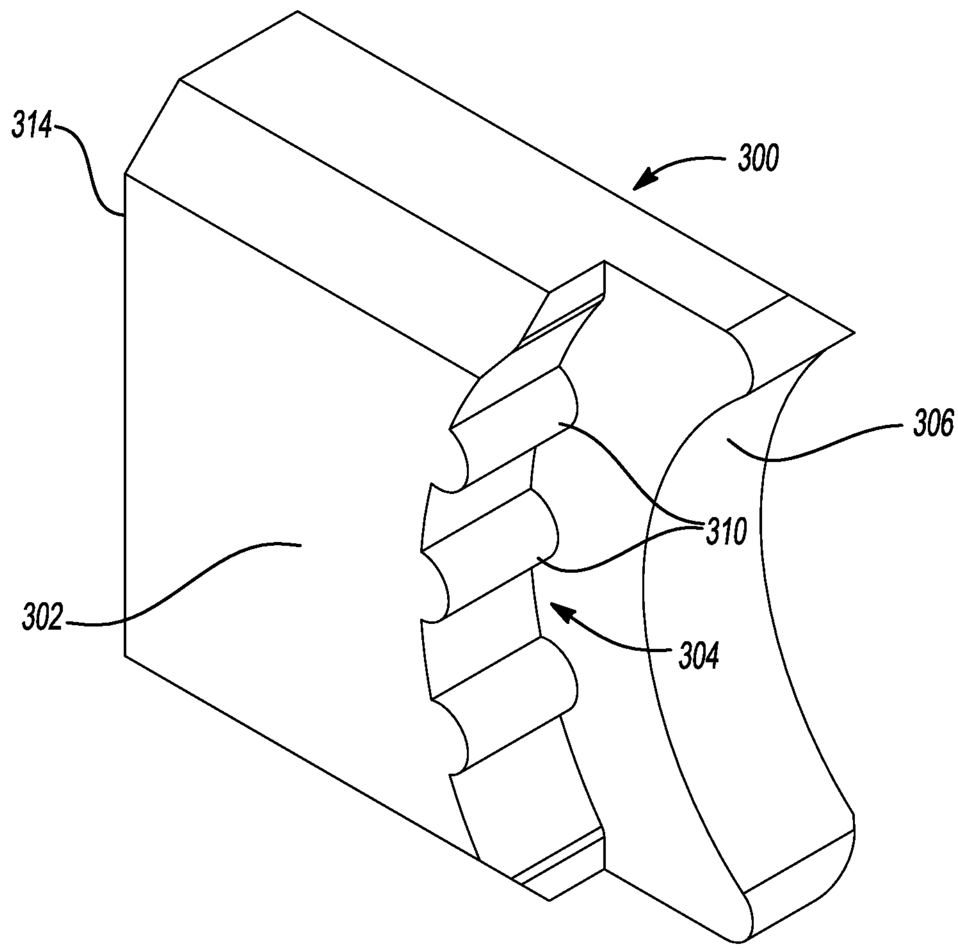


Fig-7

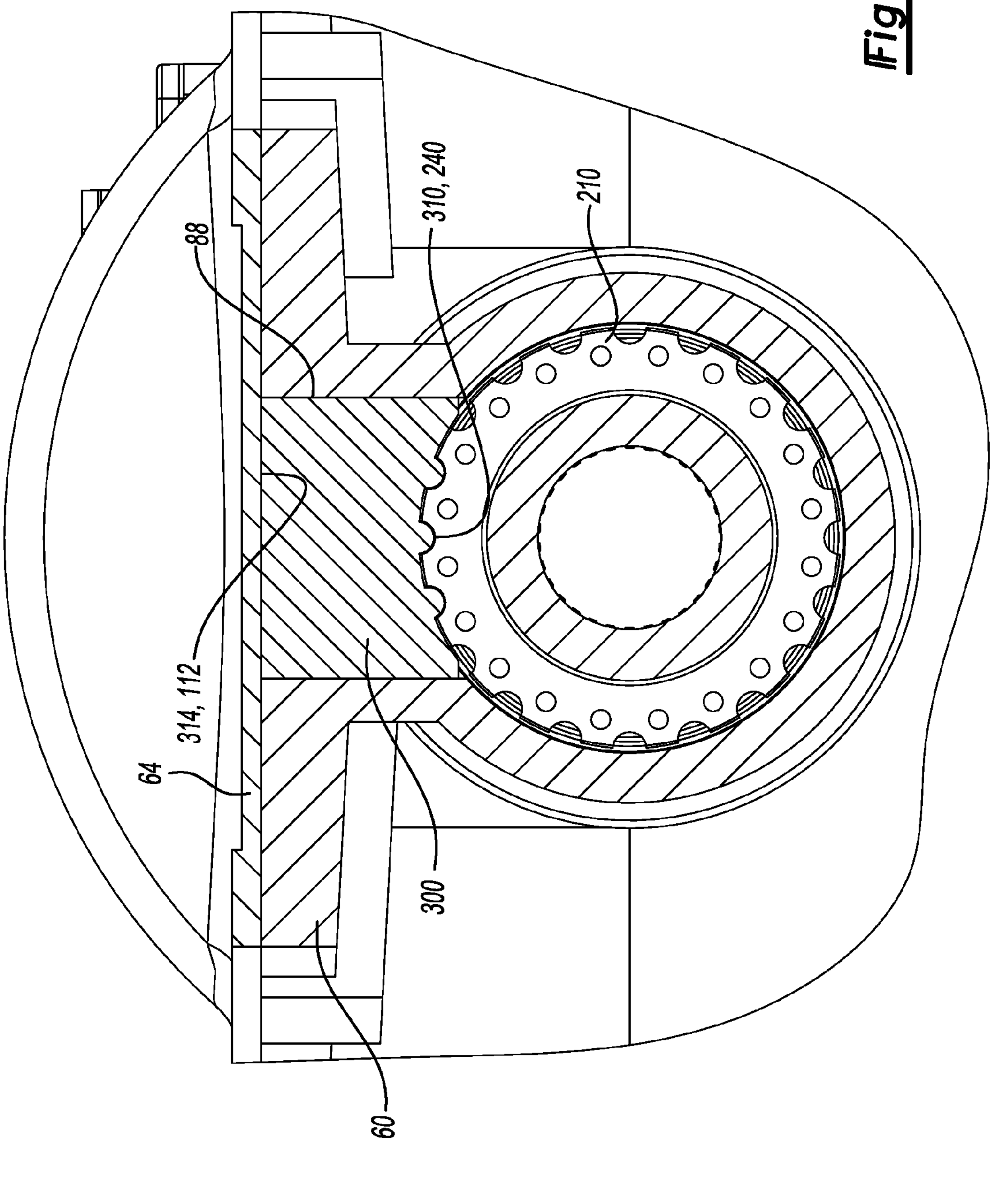


Fig-8

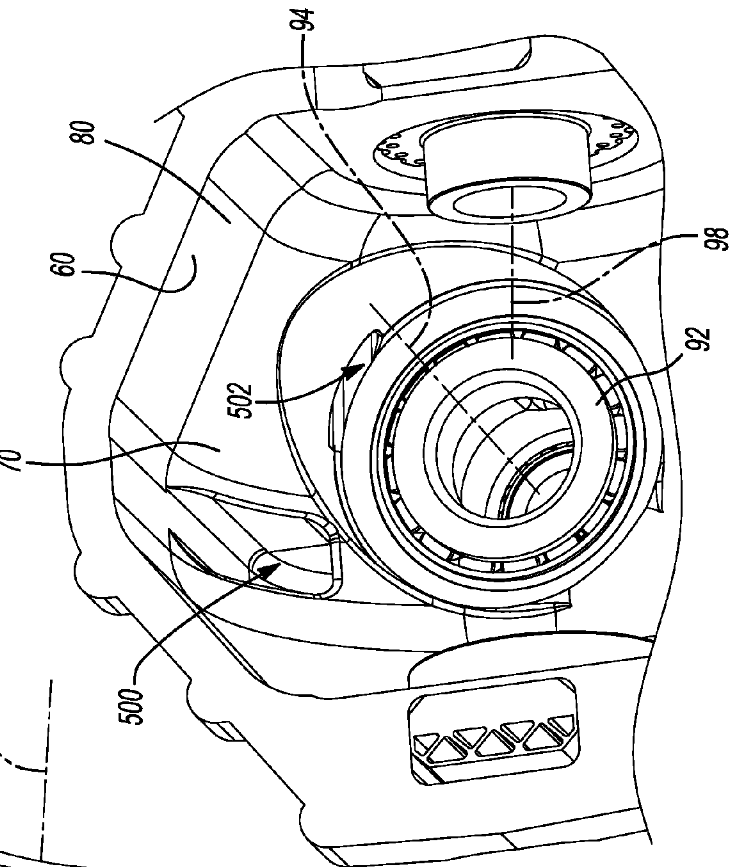


Fig-10

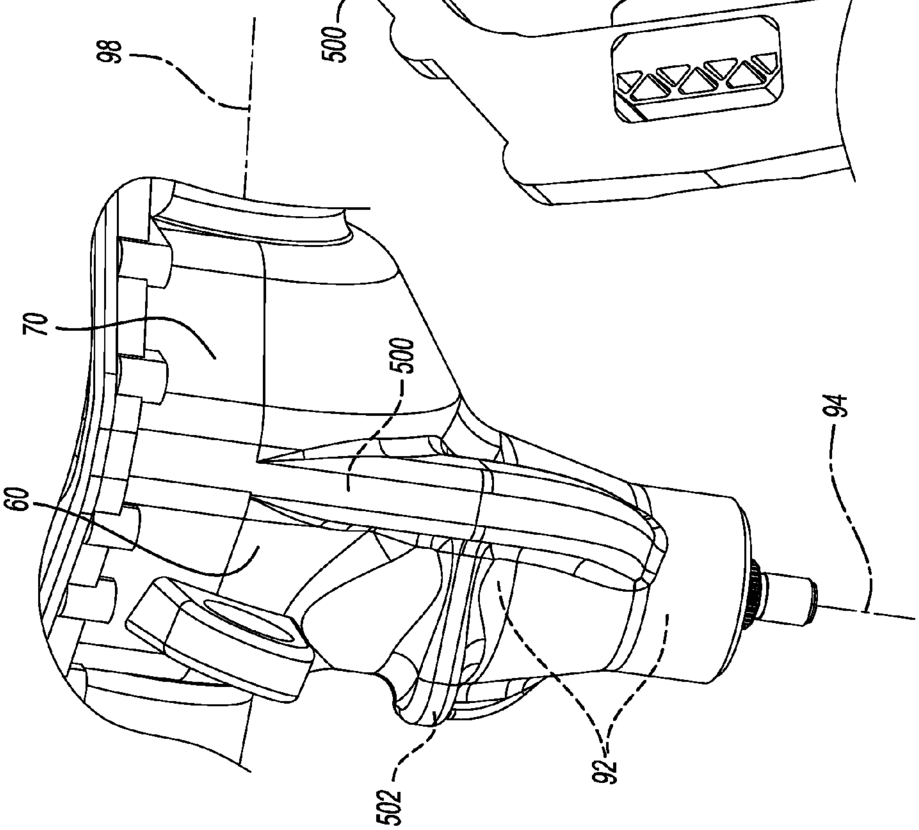
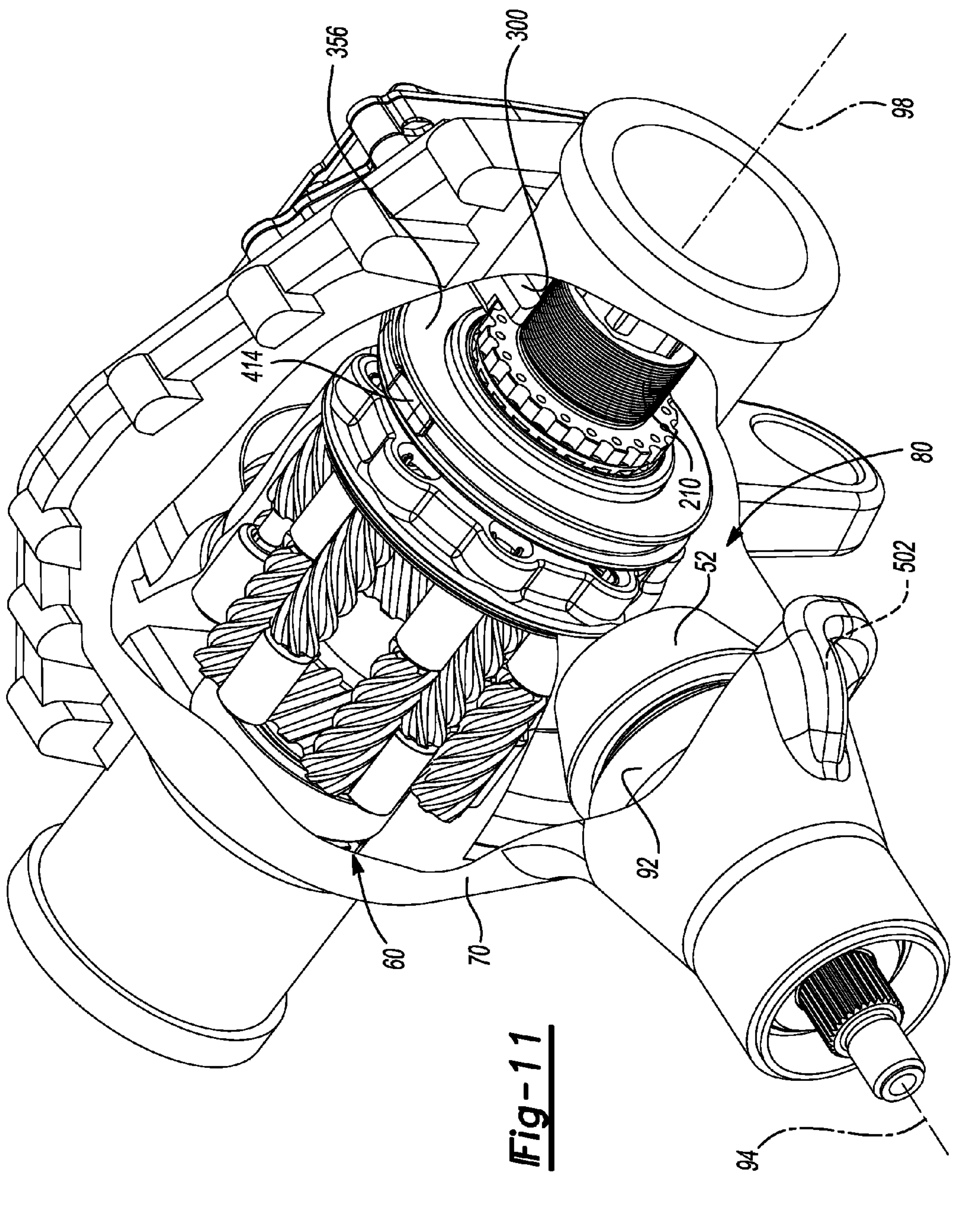


Fig-9



Fig–11

AXLE ASSEMBLY HAVING DIFFERENTIAL ASSEMBLY WITH INVERTED DIFFERENTIAL BEARINGS

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. application Ser. No. 14/529,422 filed Oct. 31, 2014, which claims the benefit of U.S. Provisional Application No. 61/983,092, filed on Apr. 23, 2014. The disclosure of each of the above-referenced applications is incorporated by reference as if set forth in their entirety herein.

FIELD

The present disclosure relates to an axle assembly having a differential assembly with inverted differential bearings.

BACKGROUND

This section provides background information related to the present disclosure which is not necessarily prior art.

In the field of off-roading, beam axle assemblies are perceived as providing advantages over other types of axle assemblies when operating in certain types of terrain, such as when rock crawling. These advantages include the perception of increased durability, as well as the articulation of the entire axle assembly when traversing uneven terrain so that the position of the differential can be shifted as a function of the position of the wheels of the axle assembly so as to better avoid contact between an obstruction and the portion of the axle assembly that houses the differential. While the known beam axle assemblies are satisfactory for their intended use, there nevertheless remains a need in the art for an improved beam axle.

SUMMARY

This section provides a general summary of the disclosure, and is not a comprehensive disclosure of its full scope or all of its features.

In one form, the present disclosure provides an axle assembly that includes a housing assembly, a differential assembly, a pair of differential bearings and a pair of bearing adjusters. The housing assembly has a carrier housing and a pair of axle tubes. The carrier housing has a carrier body and a pair of tube mounts that are disposed on opposite lateral sides of the carrier body. The carrier body has a wall that defines a differential cavity and a pair of bulkheads. Each of the bulkheads is integrally, unitarily and non-separably formed with a remaining portion of the wall and defines a through bore with a set of internal threads. The tube mounts are in fluid connection with the through bores and the differential cavity. Each of the axle tubes is received in an associated one of the tube mounts and is fixedly coupled to the carrier housing. The differential assembly is received in the cavity and has a differential case with opposite lateral ends. A bearing bore is formed in each of the opposite lateral ends of the differential case. Each of the differential bearings has an outer bearing race that is received in an associated one of the bearing bores and engaged to the differential case. Each bearing adjuster has a threaded portion and a bearing mount portion. The threaded portion is threadably engaged to the internal threads of an associated one of the bulkheads. The bearing mount portion is disposed on a first end of the bearing adjuster that is opposite a second end on which the threaded portion is formed. The bearing mount portion defines a shoulder against which an associated one of the differential bearings is abutted. The bearing mount portion supports a side of the associated one of the differential bearings that is opposite the differential case such that each differential bearing is in juxtaposed relation with the differential case and an associated one of the bearing adjusters.

In another form, the present disclosure provides an axle assembly with a housing assembly, a differential assembly, a first differential bearing, a first bearing adjuster and an adjuster lock. The housing assembly has a carrier housing, a pair of axle tubes and a cover. The carrier housing has a carrier body and a tube mount. The carrier body has a wall that defines a cavity, a first bulkhead, a cover flange and a lock member aperture. The first bulkhead is integrally, unitarily and non-separably formed with a remaining portion of the wall and defines a through bore with a set of internal threads. The cover flange borders an open side of the cavity and has a flange member. The lock member aperture is formed through the cover flange and intersects the cavity. The tube mount is in fluid connection with the through bore and the differential cavity. The axle tube is received in the tube mount and is fixedly coupled to the carrier housing. The differential assembly is received in the cavity and has a differential case with opposite lateral ends. A bearing bore is formed in a first one of the lateral ends of the differential case. The first differential bearing has an outer bearing race that is received in the bearing bore and engaged to the differential case. The first bearing adjuster has a threaded portion, a bearing mount portion and an adjuster lock portion. The threaded portion is threadably engaged to the internal threads of the first bulkhead. The adjuster lock portion is disposed axially between opposite axial ends of the first bearing adjuster and has a plurality of circumferentially spaced apart locking features. The adjuster lock member is received in the lock member aperture and has a plurality of mating locking features that are engaged to a portion of the locking features on the first bearing adjuster. The cover is sealingly engaged to the flange member and abuts the adjuster lock member to limit movement of the adjuster lock member in the adjuster lock aperture in a direction away from the first bearing adjuster.

Further areas of applicability will become apparent from the description provided herein. The description and specific examples in this summary are intended for purposes of illustration only and are not intended to limit the scope of the present disclosure.

DRAWINGS

The drawings described herein are for illustrative purposes only of selected embodiments and not all possible implementations, and are not intended to limit the scope of the present disclosure.

FIG. **1** is a schematic illustration of a vehicle having exemplary axle assemblies constructed in accordance with the teachings of the present disclosure;

FIG. **2** is a bottom perspective view of a portion of the vehicle of FIG. **1**, illustrating the rear axle assembly in more detail;

FIG. **3** is an exploded bottom perspective view of the rear axle assembly;

FIG. **4** is a section view of a portion of the rear axle assembly taken along the line **4-4** of FIG. **2**;

FIG. **5** is an exploded perspective view of a portion of the rear axle assembly illustrating a portion of the differential assembly and the locking mechanism in more detail;

FIG. **6** is a perspective view of a portion of the rear axle assembly illustrating a differential bearing adjuster and an adjuster lock in more detail;

FIG. **7** is a perspective view of the adjuster lock;

FIG. **8** is a section view of a portion of the rear axle assembly taken along the line **8-8** of FIG. **2**;

FIG. **9** is a top perspective view of a portion of the rear axle assembly, illustrating a portion of a carrier housing in more detail;

FIG. **10** is a perspective of a portion of the rear axle assembly, illustrating a portion of the interior of the carrier housing in more detail; and

FIG. **11** is a perspective, partly broken-away view of a bottom portion of the rear axle assembly.

Corresponding reference numerals indicate corresponding parts throughout the several views of the drawings.

DETAILED DESCRIPTION

With reference to FIG. **1** of the drawings, an exemplary vehicle **10** is illustrated to include a powertrain **12** and a drivetrain **14**. The powertrain **12** can include a prime mover **20** and a transmission **22**. The prime mover **20** can be an internal combustion engine or an electric motor and can be configured to provide rotary power to the transmission **22**. The transmission **22** can be any type of transmission, such as a manual, automatic or continuously variable transmission, and can be configured to provide rotary power to the drivetrain **14**.

The drivetrain **14** can include a transfer case **32**, a rear propshaft **34**, a rear axle assembly **36**, a front propshaft **38** and a front axle assembly **40**. The transfer case **32** can receive rotary power from the transmission **22**. The rear propshaft **34** can be drivingly coupled to a rear output **42** of the transfer case **32** and can transmit rotary power to the rear axle assembly **36**. The rear axle assembly **36** can be configured to transmit rotary power to a set of rear vehicle wheels **44**. The front propshaft **38** can be drivingly coupled to a front output **46** of the transfer case **32** and can transmit rotary power to the front axle assembly **40**. The front axle assembly **40** can be configured to transmit rotary power to a set of front vehicle wheels **48**. The rear and front axle assemblies **36** and **40** can be constructed in accordance with the teachings of the present disclosure. As the front axle assembly **40** is generally similar to the rear axle assembly **36**, only the rear axle assembly **36** will be discussed in detail herein.

With reference to FIGS. **2** and **3**, the rear axle assembly **36** is shown in more detail. The rear axle assembly **36** can include a housing assembly **50**, an input pinion **52**, a differential assembly **54**, a ring gear **56** and a locking mechanism **58**.

The housing assembly **50** can comprise a carrier housing **60**, a pair of axle tubes **62** and a housing cover **64**. The carrier housing **60** can be formed of any suitable material, such as an A206 aluminum alloy material (e.g., 206-T4, 206-T7), and can define a body portion **70** and a pair of tube mounts **72**.

With reference to FIGS. **3** and **4**, the body portion **70** can define a cavity **80** that is configured to receive the differential assembly **54** therein. The body portion **70** can include a pinion mount portion **82**, a pair of bulkheads **84**, a first flange **86** and a pair of lock mounts **88**. The pinion mount portion **82** is configured to receive a pair of pinion bearings **92** that support a shaft portion of the input pinion **52** for rotation about a first axis **94** relative to the carrier housing **60**. Each of the bulkheads **84** can be unitarily and integrally formed with a remainder of the carrier housing **60** such that they cannot be removed from the remainder of the carrier housing **60**. Each of the bulkheads **84** can define a threaded aperture **96** that can be disposed about a second axis **98** concentrically with an associated one of the tube mounts **72**. The first flange **86** is configured to cooperate with the housing cover **64** to close the cavity **80** and as such, the first flange **86** can generally extend about the perimeter of the cavity **80**. In the example provided, the first flange **86** also extends about the lock mounts **88**. Each of the lock mounts **88** can define a recess that can extend through the first flange **86** at a location between an associated one of the bulkheads **84** and the cavity **80**. In the particular example provided, an intermediate wall **100** on the first flange **86** separates each of lock mounts **88** from the cavity **80**, but it will be appreciated that the recesses defined by the lock mounts **88** could intersect the portion of the cavity **80** that is formed through the first flange **86**.

The tube mounts **72** can be disposed on opposite lateral sides of the body portion **70** and each of the tube mounts **72** can be configured to receive an associated one of the axle tubes **62**, for example in a press-fit manner. If desired, the axle tubes **62** can be secured to the tube mounts **72** in a manner that inhibits axial movement of the axle tubes **62** relative to the tube mounts **72**, such as slug welding.

The housing cover **64** can be removably coupled to the body portion **70** of the carrier housing **60** to substantially close the cavity **80** that is formed in the body portion **70**. The housing cover **64** can define a second flange **110**, a pair of abutment members **112** and an actuator mount **114**. The second flange **110** can be configured to cooperate with the first flange **86** on the body portion **70** to form a sealing interface. It will be appreciated that a gasket (not specifically shown) or sealant material can be received between the first and second flanges **86** and **110** to a form a seal therebetween. The abutment members **112** can be shaped in any desired manner and can be disposed in-line with the lock mounts **88** when the housing cover **64** is installed to the carrier housing **60**. In the example provided, the abutment members **112** are co-formed with the second flange **110** such that the portions of the inner surface of the housing cover **64** that are defined by the second flange **110** and the abutment members **112** are co-planar. It will be appreciated, however, that the abutment members **112** may be shaped differently and that they may extend on one side or the other of the plane that is defined by the inside surface of the second flange **110**. The actuator mount **114** can define a mounting flange **118** that can border an actuator aperture **120** that extends through the housing cover **64** and is configured to provide a means for portion of the locking mechanism **58** to access structure that is mounted in the cavity **80**. A portion of the locking mechanism **58** can be secured to the housing cover **64** via the actuator mount **114** as will be described in greater detail, below.

The differential assembly **54** can include a differential case assembly **130**, a pair of output members **132** and a power transmitting means **134**. The output members **132** are rotatably disposed about the second axis **98** and can be drivingly coupled to a pair of axle shafts (not specifically shown).

With reference to FIGS. **4** and **5**, the differential case assembly **130** can include a case body **140** and a cap **142** that can be fixedly coupled to one another by any desired means, including threaded fasteners. In the particular example provided, the cap **142** is welded to the case body **140**. The case body **140** and the cap **142** can cooperate to define a differential cavity **146** into which the output members **132**, a portion of the locking mechanism **58**, and the power transmitting means **134** can be received. The case body **140** can include an annular case wall **148**, which is sized to be received through the ring gear **56**, and a flange member **150** that can extend radially outwardly from the case wall **148**. The ring gear **56** can be mounted to the flange member **150** in any desired manner, such as via a plurality of threaded fasteners or via welding, and can be meshingly engaged with the input pinion **52** (FIG. **3**). In the particular example provided, the ring gear **56** and the input pinion **52** (FIG. **3**) are oriented in the carrier housing **60** to form a "high offset" hypoid gearset in which the first axis **94** is located vertically above the second axis **98**.

As best shown in FIG. **4**, the case body **140** and the cap **142** can define bearing mounts **160** for a pair of differential bearings **162**. In the particular example provided, each of the bearing mounts **160** is formed by counterbores that are formed into the annular wall member **148** and the cap **142**. The counterbores define an outer annular wall **166** and a shoulder **168**. The counterbores receive the differential bearings **162** such that the outer bearing race of each of the differential bearings **162** is engaged to the outer annular wall **166** and abutted against the shoulder **168** of a corresponding one of the counterbores. Construction of the differential case assembly **130** in this manner (i.e., with inverted differential bearings) reduces the width of the differential case assembly **130** as compared with a conventionally constructed and mounted differential case construction.

With reference to FIGS. **3** and **5**, the power transmitting means **134** can be any type of device or mechanism for transmitting rotary power between the differential case assembly **130** and the output members **132**, and can comprise one or more clutches and/or a differential gearset. In the example provided, the power transmitting means **134** comprises a differential gearset having first and second helical side gears **180** and **182** and a plurality of differential pinion sets **184**. The first and second helical side gears **180** and **182** can be received in the differential cavity **146** and can be coupled to the output members **132** for common rotation about the second axis **98**. The differential gearset can be configured with any number of differential pinion sets **184**, but in the particular example provided, the differential gearset includes six (6) differential pinion sets **184**. Each differential pinion set **184** can have a first differential pinion **190**, a second differential pinion **192**, and a pair of brake shoes **194**. The first differential pinions **190** can be received into first pinion cavity portions **200** of the differential cavity **146** and can have helical teeth that can be meshingly engaged with the teeth of the first helical side gear **180**. The second differential pinions **192** can be received into second pinion cavity portions **202** of the differential cavity **146**. Each of the second differential pinions **192** can have helical teeth that can be meshingly engaged with the teeth of the second helical side gear **182** as well as the teeth of a corresponding one of the first differential pinions **190**. Each of the brake shoes **194** can be received on a shaft end **206** (FIG. **3**) of a corresponding one of the first and second differential pinions **190** and **192** and can be received in an associated one of the first and second cavity portions **200** and **202** so as to non-rotatably engage the case body **140** or the cap **142**.

It will be appreciated that welding of the cap **142** to the case body **140** could produce distortions in the case body **140** that could impact the engagement of the first and second differential pinions **190** and **192** with the surfaces of the first and second cavity portions **200** and **202**, respectively. In the particular example provided, the weld W (FIG. **3**) between the cap **142** and the case body **140** is axially offset and radially outward from the first and second cavity portions **200** and **202** so as to reduce the risk of distortion induced by the welding of the cap **142** to the case body **140**.

With reference to FIGS. **4** and **6**, a pair of differential bearing adjusters **210** can be employed to provide journals **212** onto which the differential case assembly **130** can rotate relative to the carrier housing **60**, as well as to both pre-load the differential bearings **162** and to position the differential case assembly **130** in a lateral direction to thereby effect the meshing of the ring gear **56** to the input pinion **52** (FIG. **3**). Each of the differential bearing adjusters **210** can define a central aperture **220**, which can extend longitudinally through the differential bearing adjuster **210**, a housing engagement portion **222**, a bearing engaging portion **224**, a tool engaging portion **226** and a locking portion **228**. The housing engagement portion **222** can comprise an externally threaded segment that can be threadably engaged to the threaded aperture **96** in a corresponding one of the bulkheads **84** in the body portion **70** of the carrier housing **60**. The bearing engaging portion **224** can comprise the journal **212**, which is configured to engage the inner bearing race of an associated one of the differential bearings **162**, and a shoulder **232** that is configured to abut the inner bearing race of the associated one of the differential bearings **162**. The tool engaging portion **226** is configured to engage a tool (not shown) to permit a technician to rotate the differential bearing adjuster **210** relative to the carrier housing **60**. In the particular example provided, the tool engaging portion **226** comprises a hexagonal aperture **236**, which is coincident with a portion of the central aperture **220** and is configured to drivingly engage a correspondingly shaped tool, and a plurality of holes **238** that can be spaced circumferentially about the shoulder **232** radially outwardly of the housing engagement portion **222**. The former tool engaging means may be suited for high volume production prior to the installation of the axle shafts (not specifically shown), whereas the latter tool engaging means may be suited for repair or service. It will be appreciated, however, that redundant tool engagement means need not be provided, and the tool engagement means provided by the tool engaging portion **226** could be shaped differently. The locking portion **228** can comprise a plurality of circumferentially spaced-apart locking features **240** that can be disposed about the circumference of the differential bearing adjuster **210**. In the particular example provided, the locking features **240** are shaped in a negative manner (i.e., the locking features **240** are defined by material that is removed from or not present in a portion of the differential bearing adjuster **210**) in which each of the locking features **240** is a groove that extends generally parallel to a longitudinal axis of the differential bearing adjuster **210**. However, those of skill in the art will appreciate that the locking features **240** could be shaped in a positive manner (i.e., the locking features **240** can be defined by material that is present on a portion of the differential bearing adjuster **210**). The locking portion **228** can be located axially along the length of the differential bearing adjuster **210** so as to be positioned in-line with one of the lock mounts **88** in the carrier housing **60** when the differential assembly **54** is mounted to the carrier housing **60** and positioned laterally relative to the carrier housing **60** in a desired manner.

With reference to FIGS. **4**, **6** and **7**, a pair of adjuster locks **300** can be employed to inhibit rotation of the differential bearing adjusters **210** relative to the carrier housing **60**. Each of the adjuster locks **300** can be formed of a suitable material, such as a plastic or powdered metal material, and can have a lock body **302**, a locking profile **304** and a lock flange **306**. The lock body **302** is configured to be slidably received into the recess of a corresponding one of the lock mounts **88** (FIG. **3**) so that the adjuster lock **300** is maintained in a predetermined position relative to the carrier housing **60**. The locking profile **304** can be configured to engage the differential bearing adjusters **210** to inhibit rotational movement of a corresponding one of the differential bearing adjusters **210** relative to the carrier housing **60**. The locking profile **304** can comprise mating locking features **310** that can engage a portion of the locking features **240** on the corresponding one of the differential bearing adjusters **210**. In the example provided, the locking profile **304** comprises a plurality of spline members that are configured to be received into a sub-set of the locking features **240** that are aligned to the lock mounts **88**. The lock flange **306** can be sized and positioned to contact the shoulder **232** on the differential bearing adjuster **210** to prevent the adjuster lock **300** from being fully inserted into the carrier housing **60** if the differential bearing adjuster **210** is not positioned within predefined limits.

With additional reference to FIG. **8**, when the differential bearing adjusters **210** have been positioned so as to preload the differential bearings **162** to a desired degree and to position the differential assembly **54** and ring gear **56** laterally within the carrier housing **60** as desired, the adjuster locks **300** can be received into the lock mounts **88** so that the mating locking features **310** on the locking profile **304** can matingly engage the locking features **240** on the differential bearing adjusters **210**. In situations where the differential bearing adjusters **210** are oriented relative to the carrier housing **60** such that the mating locking features **310** matingly engage the locking features **240**, the outer ends **314** of the adjuster locks **300** can be spaced in a desired manner from the abutment members **112** such that the second flange **110** can be properly positioned relative to the first flange **86** (i.e., so that the housing cover **64** can be sealed against the carrier housing **60**). In practice, a small amount of clearance can be disposed between the outer ends **314** of the adjuster locks **300** and the abutment members **112**; the clearance, however, is relatively small so that the adjuster locks **300** cannot move relative to the differential bearing adjusters **210** and the housing cover **64** by an amount that is sufficient to permit the mating locking features **310** from disengaging the locking features **240**. In situations where the differential bearing adjusters **210** are oriented relative to the carrier housing **60** such that the mating locking features **310** do not matingly engage the locking features **240**, the outer ends **314** of the adjuster locks **300** can be spaced from the abutment members **112** such that the second flange **110** can be improperly positioned relative to the first flange **86** (i.e., so that the housing cover **64** cannot be sealed against the carrier housing **60**). Construction in this manner permits the adjuster locks **300** to be "dropped into" the carrier housing **60** and eliminates the need for specific installation tools.

With renewed reference to FIG. **3**, the height of the carrier housing **60** can be reduced by machining a plurality of surfaces **330** on the interior of the carrier housing **60** to ensure that there is clearance between the carrier housing **60** and the ring gear **56** and that the clearance is smaller in magnitude than would be possible to obtain in view of stack-up tolerances and conventional casting tolerances to control the location of the interior surfaces **330**. In the example provided, the clearance between the interior surfaces **330** of the carrier housing **60** and the ring gear **56** is less than or equal to 2.0 mm (0.08 inch), preferably less than or equal to 1.5 mm (0.06 inch) and more preferably less than or equal to about 1.0 mm (0.04 inch).

With reference to FIG. **5**, the locking mechanism **58** can comprise a first dog ring **350**, a second dog ring **352**, a plunger **354**, a sleeve or lock collar **356** and an actuator assembly **358**. The first and second dog rings **350** and **352** can be generally similar to the first and second dog rings described in detail in commonly assigned U.S. Pat. No. 7,425,185, the disclosure of which is incorporated by reference as if fully set forth in detail herein. Briefly, the first dog ring **350** can comprise a plurality of first face teeth formed on a surface of the second helical side gear **182** that faces the cap **142**, while the second dog ring **352** can be disposed between the first dog ring **350** and the cap **142** and can have a plurality of second face teeth and a plurality of locking members **360** that can be received into locking recesses **362** that can be formed through the cap **142**. The locking members **360** engage the cap **142** so as to axially slidably but non-rotatably couple the second dog ring **352** to the cap **142**. It will be appreciated that engagement of the second face teeth to the first face teeth non-rotatably couples the second helical side gear **182** to the differential case assembly **130** to thereby lock the power transmitting means **134** and inhibit speed/torque differentiation between the output members **132**. The plunger **354** can comprise a plurality of legs **370** and a plunger body **372**. Each of the legs **370** can be a pin-shaped structure that can be axially slidably received in one of the locking recesses **362** in the cap **142** and abutted against one of the locking members **360**. The plunger body **372** can be fixedly coupled to the legs **370** and to the second dog ring **352**. In the example provided, the plunger body **372** is formed of a metallic ring and a plastic material that is overmolded onto (i.e., cohesively bonded to) the metallic ring, the legs **370** and the locking members **360** on the second dog ring **352**. The legs **370** can be moved within the locking recesses **362** to position the second dog ring **352** in a first position, in which the second face teeth are spaced apart from the first face teeth so that rotation of the second helical side gear **182** relative to the cap **142** is not restricted, and a second position in which the second face teeth are engaged to the first face teeth inhibit rotation of the second helical side gear **182** relative to the cap **142**.

With reference to FIGS. **3** and **5**, the lock collar **356** can be mounted to the differential case, such as to the cap **142**, and can be coupled to the differential case for common rotation. In the particular example provided, the lock collar **356** is non-rotatably coupled to the cap **142** and axially movable along the second axis **98** between a first sleeve position and a second sleeve position. In the particular example provided, the cap **142** defines a plurality of longitudinally extending ridges **380** and the lock collar **356** is matingly contoured so as to slide along the ridges **380** but not rotate relative to the cap **142**. The lock collar **356** can comprise an engagement surface **384**, which can be fixedly coupled to the legs **370** of the plunger **354**, and a circumferential groove **386**.

The actuator assembly **358** can be similar to the actuator assembly described in co-pending and commonly assigned U.S. Provisional Patent Application No. 61/869,282 filed Aug. 23, 2013 entitled "Power Transmitting Component With Twin-Fork Actuator", the disclosure of which is incorporated by reference as if fully set forth in detail herein. Briefly, the actuator assembly **358** can comprise an actuator housing **400**, a motor **402**, a transmission **404**, a lead screw (not specifically shown), a cradle rail **408**, a fork rail (not specifically shown), a cradle assembly **412**, a clutch fork **414**, and a biasing spring (not specifically shown). The actuator housing **400** is configured to at least partly house the remaining components of the actuator assembly **358** and can be mounted to the mounting flange **118** (FIG. **3**) of the actuator mount **114** (FIG. **3**) to close the actuator aperture **120** (FIG. **3**). The motor **402** can be an electric motor that can drive the lead screw through the transmission **404**. The cradle rail **408** and the fork rail can be fixedly coupled to actuator housing **400** and can be disposed generally parallel to a rotational and longitudinal axis of the lead screw. The cradle assembly **412** can be threadably coupled to the lead screw and can include a cradle and a compliance spring. The cradle can be slidably mounted on the cradle rail **408** and the fork rail. The compliance spring can be disposed between the cradle and the lead screw and can be configured to permit axial movement of the compliance spring relative to the cradle in at least one direction. The clutch fork **414** can be slidably mounted on the fork rail and can include a pair of arms **420** that can be received into the circumferential groove **386** in the lock collar **356**. The biasing spring can be disposed on the fork rail between the clutch fork **414** and the cradle. The biasing spring can bias the clutch fork **414** along the fork rail in a predetermined direction relative to the cradle assembly **412**.

In operation, the motor **402** can be operated to drive the lead screw to cause corresponding motion of the cradle assembly **412** along the fork rail. Motion of the cradle assembly **412** in a first direction along the fork rail can cause corresponding motion of the clutch fork **414**, which can drive the lock collar **356** (and thereby the plunger **354** and the second dog ring **352**) toward the second sleeve position such that the second dog ring **352** is moved toward its second position. In the event that motion of the clutch fork **414** in the first direction is halted due to tooth-on-tooth contact of the second face teeth with the first face teeth, the biasing spring can be compressed to permit the cradle assembly **412** to be positioned and to exert a force onto the clutch fork **414** that causes the clutch fork **414** to move in the first direction (to cause driving engagement of the second face teeth with the first face teeth) when the first face teeth have been positioned rotationally relative to the second face teeth in a manner that permits the second dog ring **352** to shift fully against the first dog ring **350**.

Motion of the cradle assembly **412** in a second, opposite direction along the fork rail can cause corresponding motion of the clutch fork **414**, which can drive the lock collar **356** toward the first sleeve position (and thereby the plunger **354** and the second dog ring **352**) such that the second dog ring **352** is moved toward its first position. In the event that motion of the clutch fork **414** in the second direction is halted due to torque-locking of the second face teeth with the first face teeth, the compliance spring can be compressed to permit the cradle to be positioned and to exert a force onto the clutch fork **414** that causes the clutch fork **414** to move in the second direction (to cause disengagement of the second face teeth from the first face teeth).

It will be appreciated that the configuration of the bearing adjusters **210** that is depicted herein permits the carrier housing **60** to be relatively narrow in its width. For example, the locking collar **356** can be disposed concentrically about one of the differential bearings **162** so that the rear axle assembly **36** can be provided with locking capabilities without a corresponding need to widen the carrier housing **60**. In this regard, at least a portion of the locking collar **356** can be radially in-line with at least a portion of one of the differential bearings **162** when the locking collar **356** is in at least one of the first and second sleeve positions such that a plane P taken perpendicular to the second axis **98** extends through both the locking collar **356** and one of the differential bearings **162**.

With renewed reference to FIGS. **1** and **3**, many of the components of the particular rear axle assembly **36** described herein and illustrated in the accompanying drawings are configured such that they can also be employed in the front axle assembly **40**. Those of skill in the art will appreciate that because the output members **132** of the differential assembly **54** must rotate in a common rotational direction, the orientation of the carrier housing **60** must be rotated 180 degrees about (i.e., mirrored about) the second axis **98** and can optionally be rotated 180 degrees about (i.e., mirrored about) the first axis **94**. In the particular example provided, the carrier housing **60** is mirrored about both the first and second axes **94** and **98**. Configuration in this manner orients the input pinion **52** so as to receive rotary power from the transfer case **32**, as well as causes the meshing of the input pinion **52** and the ring gear **56** to occur on an opposite lateral side of the first axis **94**. Configuration in this manner also causes the ring gears **56** of the rear and front axle assemblies **36** and **40** to rotate in opposite rotational directions (relative to the carrier housing **60**). This latter point is significant because the ring gear **56** of the rear axle assembly **36** is employed to provide lubrication to the pinion bearings **92** via sling lubrication. Sling lubrication involves the rotation of the ring gear **56** through a lubricant-containing sump in the carrier housing **60** and the subsequent outward slinging of the lubricant from the ring gear **56** due to centrifugal force when the ring gear **56** rotates in a predetermined rotational direction (which corresponds to operation of the vehicle in a predetermined, e.g., forward, direction). Typically, lubricant slung from a ring gear **56** can be directed via lubricant galleries in a desired manner to lubricate various bearings within the rear axle assembly **36**. When the rotational direction of the ring gear **56** relative to the carrier housing **60** is changed, however, the lubricant slung from the ring gear **56** will travel in a different direction relative to the carrier housing **60**. Accordingly, we have configured the carrier housing **60** with alternate lubrication galleries for providing lubricant to the pinion bearings **92** when the carrier housing **60** is oriented differently (e.g., mirrored about the first and second axes **94** and **98**). Those of skill in the art will appreciate that in a situation where the carrier housing **60** is mirrored about the first and second axes **94** and **98**, contact between the input pinion **52** and the ring gear **56** will additionally interfere with the slinging of lubrication when the vehicle is operated in the predetermined direction.

With reference to FIGS. **9** through **11**, the body portion **70** of the carrier housing **60** can define a first lubricant gallery **500** and a second lubricant gallery **502**. Optionally, the structure that forms the first lubricant gallery **500** and/or the structure that forms the second lubricant gallery **502** can be employed to strengthen portions of the carrier housing **60**. In the particular example provided, the structures that form the first and second lubricant galleries **500** and **502** form ribs on the exterior of the remainder of the carrier housing **60** that strengthen desired portions of the carrier housing **60**. For example, the structure that forms the second lubricant gallery **502** is configured to support the portion of the carrier housing **60** that is loaded by the input pinion **50** during operation of the axle assembly when the vehicle is operated in a predetermined (e.g., forward) direction.

The first lubricant gallery **500** can define a channel that extends between the cavity **80** and the portion of the carrier housing **60** to which the pinion bearings **92** (FIG. **2**) are mounted. The end of the first lubricant gallery **500** that intersects the cavity **80** can be oriented to receive lubricant that is slung from the ring gear **56** (FIG. **3**) when the carrier housing **60** is used for the rear axle assembly **36** (FIG. **1**) and the vehicle **10** (FIG. **1**) is operated in a forward direction. Accordingly, the end of the first lubricant gallery **500** that interests the cavity **80** can be oriented vertically above the second axis **98** (FIG. **5**). The first lubricant gallery **500** can be sloped so as to drop vertically with decreasing distance toward the pinion bearings **92** (FIG. **3**) when the carrier housing **60** is oriented for use in the rear axle assembly **36** (FIG. **1**). Configuration in this manner permits the first lubricant gallery **500** to be employed to feed (via gravity) lubricant from the cavity **80** to the pinion bearings **92** (FIG. **3**) when the carrier housing **60** is oriented for use in the rear axle assembly **36** (FIG. **1**). When the carrier housing **60** is mirrored about the first and second axes **94** and **98** for use in the front axle assembly **40** (FIG. **1**), the first lubricant gallery **500** is configured to drain excess lubricant from the pinion bearings **92** (FIG. **3**) to the cavity **80**.

The second lubricant gallery **502** can define a channel that extends between the cavity **80** and the portion of the carrier housing **60** to which the pinion bearings **92** (FIG. **2**) are mounted. The end of the second lubricant gallery **502** that intersects the cavity **80** can be oriented to receive lubricant that is slung from the gear portion of the input pinion **52** (FIG. **3**) when the carrier housing **60** is used for the front axle assembly **40** (FIG. **1**) and the vehicle **10** (FIG. **1**) is operated in a forward direction. Accordingly, the end of the second lubricant gallery **502** that interests the cavity **80** can be oriented vertically below the end of the first lubricant gallery **500** that intersects the cavity **80** and on a side of the first axis **94** that is opposite the end of the first lubricant gallery **500** that intersects the cavity **80**. When the carrier housing **60** is oriented for use in the rear axle assembly **36** (FIG. **1**), the second lubricant gallery **502** can be configured to drain excess lubricant from the first lubricant gallery **500** and moreover, can be positioned to drain lubricant onto the gear portion of the input pinion **52**. When the carrier housing **60** is oriented for use in the front axle assembly **40** (FIG. **1**), lubricant can be slung from the gear portion of the input pinion **52** and can be received into the end of the second lubricant gallery **502** that intersects the cavity **80**; excess lubricant can drain to the cavity **80** through the open end of the first lubricant gallery **500**.

The foregoing description of the embodiments has been provided for purposes of illustration and description. It is not intended to be exhaustive or to limit the disclosure. Individual elements or features of a particular embodiment are generally not limited to that particular embodiment, but, where applicable, are interchangeable and can be used in a selected embodiment, even if not specifically shown or described. The same may also be varied in many ways. Such variations are not to be regarded as a departure from the disclosure, and all such modifications are intended to be included within the scope of the disclosure.

What is claimed is:

1. An axle assembly comprising:

a housing assembly that defines a pair of bores, each of the bores having a set of internal threads, the housing assembly having a carrier housing and a pair of axle tubes, the carrier housing having a carrier body and a pair of tube mounts that are disposed on opposite lateral sides of the carrier body, the carrier body having a wall that defines a differential cavity, the tube mounts being in fluid connection with the bores and the differential cavity, each of the axle tubes being received in an associated one of the tube mounts and fixedly coupled to the carrier housing;

a differential assembly received in the cavity and having a differential case with opposite lateral ends, wherein a bearing bore is formed in each of the opposite lateral ends of the differential case;

a pair of differential bearings, each of the differential bearings having an outer bearing race that is received in an associated one of the bearing bores and engaged to the differential case;

a pair of bearing adjusters, each bearing adjuster having a threaded portion and a bearing mount portion, the threaded portion being threadably engaged to an associated one of the sets of internal threads, the bearing mount portion being disposed on a first end of the bearing adjuster that is opposite a second end on which the threaded portion is formed, the bearing mount portion defining a shoulder against which an associated one of the differential bearings is abutted, the bearing mount portion supporting a side of the associated one of the differential bearings that is opposite the differential case such that each differential bearing is in juxtaposed relation with the differential case and an associated one of the bearing adjusters.

2. The axle assembly of claim **1**, wherein the threaded portion of the bearing adjusters is smaller in diameter than the shoulder of the bearing mount.

3. The axle assembly of claim **1**, wherein each of the bearing adjusters further comprises a locking portion that is disposed axially between the associated one of the differential bearings and the second end, the locking portion comprising a plurality of lock features.

4. The axle assembly of claim **3**, wherein the lock features are spaced circumferentially about an outer radial edge of the shoulder.

5. The axle assembly of claim **3**, further comprising a pair of adjuster lock members, each of the adjuster lock members being received into a corresponding lock member aperture formed into the wall of the carrier body and having mating lock features that engage a portion of the lock features formed on the associated one of the differential bearings.

6. The axle assembly of claim **5**, wherein the housing assembly further comprises a cover that is fixedly but removably coupled to the carrier housing to close a side of the cavity and wherein the cover shrouds the adjuster lock members.

7. The axle assembly of claim **6**, wherein the cover limits movement of the adjuster lock members in a direction away from the bearing adjusters such that the mating lock features cannot disengage the portion of the lock features.

8. The axle assembly of claim **1**, wherein each of the bearing adjusters comprises a first tool engaging feature that is configured to be engaged by a tool to permit the bearing adjusters to be rotated relative to the carrier housing.

9. The axle assembly of claim **8**, wherein the first tool engaging feature is formed into the shoulder on the bearing mount portion.

10. The axle assembly of claim **9**, wherein the first tool engaging feature comprises a plurality of circumferentially spaced apart holes that are formed into the shoulder and which extend generally parallel to a rotational axis about which the bearing adjusters are rotatably mounted to the carrier housing.

11. The axle assembly of claim **8**, wherein the first tool engaging feature comprises a non-circular shape that is formed on an inside surface of at least a portion of the bearing adjusters.

12. The axle assembly of claim **8**, wherein each of the bearing adjusters comprises a second tool engaging feature that is different from the first tool engaging feature, the second tool engaging feature being configured to be engaged by another tool to permit the bearing adjusters to be rotated relative to the carrier housing.

13. The axle assembly of claim **1**, wherein the wall of the carrier housing defines a pair of bulkheads, and wherein the bores are formed through the bulkheads and wherein each of the sets of internal threads are formed in an associated one of the bulkheads.

14. The axle assembly of claim **13**, wherein each of the bulkheads is integrally, unitarily and non-separably formed with a remaining portion of the wall.

15. The axle assembly of claim **1**, wherein the differential assembly further comprises a ring gear, first and second output members, and a locking element, the ring gear being coupled to the differential case for common rotation about an axis, the locking element being mounted to the differential case for movement along the axis.

16. The axle assembly of claim **15**, wherein the housing assembly includes a cover that is mounted to the carrier housing and wherein the axle assembly further comprises an actuator assembly having a sleeve and an actuator, the sleeve being mounted on the differential case and movable along the axis between a first sleeve position and a second sleeve position, the actuator being coupled to the cover and engaging the sleeve, the actuator being configured to selectively move the sleeve between the first and second sleeve positions, wherein the differential is configured to operate in an unlocked mode that permits speed differentiation between the first and second output members when the sleeve is in the first sleeve position, and wherein the differential assembly is configured to operate in a locked mode that inhibits speed differentiation between the first and second output members when the sleeve is in the second sleeve position.

17. The axle assembly of claim **16**, wherein the actuator comprises a fork that engages the sleeve.

18. The axle assembly of claim **16**, wherein the sleeve is coupled to the differential case for common rotation.

19. The axle assembly of claim **16**, wherein at least a portion of the sleeve is radially in-line with at least a portion of one of the differential bearings when the sleeve is in the first sleeve position.

20. The axle assembly of claim **16**, wherein each of the first and second output members is coupled to a side gear for common rotation.

21. An axle assembly comprising:

a housing assembly that defines a first bore with a first set of internal threads, the housing assembly having a carrier housing, a pair of axle tubes and a cover, the carrier housing having a carrier body and a tube mount, the carrier body having a wall that defines a cavity, a cover flange and a lock member aperture, the cover flange bordering an open side of the cavity and having a flange member, the lock member aperture being formed through the cover flange and intersecting the cavity, the tube mount being in fluid connection with the first bore and the cavity, the axle tube being received in the tube mount and fixedly coupled to the carrier housing;

a differential assembly received in the cavity and having a differential case;

a first differential bearing engaged to the differential case;

a first bearing adjuster having a threaded portion, a bearing mount portion and an adjuster lock portion, the threaded portion being threadably engaged to the first set of internal threads, the adjuster lock portion being disposed axially between opposite axial ends of the first bearing adjuster and having a plurality of circumferentially spaced apart locking features; and

an adjuster lock member received in the lock member aperture and having a plurality of mating locking features that are engaged to a portion of the locking features on the first bearing adjuster;

wherein the cover is sealingly engaged to the flange member and abuts the adjuster lock member to limit movement of the adjuster lock member in the adjuster lock aperture in a direction away from the first bearing adjuster.

22. The axle assembly of claim **21**, wherein the differential case has opposite lateral ends, wherein a bearing bore is formed in a first one of the lateral ends, and wherein the first differential bearing has an outer bearing race that is received in the bearing bore and is mounted to the differential case for common rotation.

23. An axle assembly comprising:

a locking differential assembly having a differential case, a ring gear coupled to the differential case for rotation therewith, first and second output members, a first dog ring, which is coupled to the first output member for common rotation, and a locking element that is movably mounted to the differential case, the locking element comprising a second dog ring;

an axle housing having a center section that defines a pinion mount portion, a cavity, an opening and a first flange that borders the opening, the opening being sized to admit the locking differential assembly there through, the locking differential assembly being received in the cavity for rotation about an axis, the ring gear extending through the opening, the flange defining a sealing surface that is parallel to and offset from the axis;

an input pinion received in the pinion mount portion, the input pinion having a stem and a pinion, the pinion being disposed in the cavity;

a pair of pinion bearings received in the pinion mount portion and supporting the stem for rotation relative to the center section;

a cover mounted to the flange to close an open side of the cavity; and

an actuator assembly coupled to the cover and comprising a plurality of legs, a sleeve and an actuator, the legs extending through the differential case and abutting the locking element and the sleeve, the sleeve being mounted on the differential case and movable along the axis between a first sleeve position and a second sleeve position, the actuator being configured to selectively move the sleeve between the first and second sleeve positions, wherein the locking differential assembly is configured to operate in an unlocked mode that permits speed differentiation between the first and second output members when the sleeve is in the first sleeve position, and wherein the locking differential assembly is configured to be operated in a locked mode that inhibits speed differentiation between the first and second output members when the sleeve is in the second sleeve position;

wherein the actuator comprises a fork that engages the sleeve.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 9,259,967 B2
APPLICATION NO. : 14/672886
DATED : February 16, 2016
INVENTOR(S) : Gregory A. Marsh et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

On the title page item 63 Related U.S. Application Data, Line 1, please delete “14/529,442,” and insert --14/529,422,--, therefor.

Signed and Sealed this
Seventeenth Day of May, 2016

Michelle K. Lee

Michelle K. Lee
Director of the United States Patent and Trademark Office